1-HOUR SO_2 NAAQS MODELING ANALYSIS
Independence County, Arkansas

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1. INTRODUCTION

Under the final U.S. EPA Sulfur Dioxide (SO_2) Data Requirements Rule (DRR) promulgated on August 21, 2015, state air agencies must develop SO_2 predictive modeling or actual monitoring information for categories of sources based on annual SO_2 emission rates. The focus of the final DRR is on areas with sources whose actual annual SO_2 emissions exceed 2,000 tons per year (tpy). EPA's rationale for using predictive dispersion modeling is the dearth of representative ambient SO_2 monitors and EPA's view that SO_2 is a "source-oriented" criteria pollutant that is relatively stable in the first few kilometers from the source. Thus, this rule directs agencies to focus on specific sources as the main contributors to SO_2 air quality impacts and the way to ascertain those potential source contributions will be through dispersion modeling.

Independence County in north, central Arkansas contains two sources that met the DRR criteria for evaluation: the Entergy Independence Steam Electric Station (Entergy) and FutureFuel Chemical Company (FutureFuel). Under a Consent Decree between EPA and environmental groups, the Arkansas Department of Environmental Quality (ADEQ) was required to designate the SO_2 attainment status for the area around Entergy in "Round 1" (no later than July 2, 2016) since the Independence Station met the Consent Decree criteria for early designation. In support of this early designation, Entergy completed the required modeling analysis of the Independence Station alone in the *SO_2 Air Dispersion Modeling Report for Independence Steam Electric Station, ERM Project No. 0268066*, dated August 2015 (the August 2015 report). ADEQ relied upon the August 2015 report in their attainment designation request to EPA. Although the results of the Entergy modeling showed attainment of the 1-hour SO_2 NAAQS, the EPA choose to designate Independence County as "Unclassifiable" pending a "Round 2" modeling evaluation considering both Entergy and FutureFuel.[1]

The enclosed SO_2 modeling analysis was completed under a subcontract with ICF Jones & Stokes, Inc. (ICF). ICF is the ADEQ's prime contractor. The analysis considers both Entergy and FutureFuel emissions for the period 2012 through 2014. ADEQ, ICF, Trinity Consultants, and the two sources have worked in close consultation with each other and with EPA during development of this analysis. The following timeline highlights the key communications throughout this process:

February 29, 2016	Conference call held between EPA Region 6, EPA Model Clearinghouse, ADEQ, FutureFuel, Entergy, and Trinity Consultants
April 29, 2016	ADEQ submits a modeling protocol to US EPA (see Appendix A)
September 29, 2016	EPA provides comments on April protocol
October 12, 2016	ADEQ responds to EPA comments on April protocol (see Appendix B)
October 18, 2016	Conference call held between EPA Region 6, ADEQ, ICF, FutureFuel, Entergy, and Trinity Consultants
October 24, 2016	Case-Specific Model Performance Report regarding Adj_u* submitted to EPA Region 6

Since this analysis uses identical inputs for Entergy as the previously accepted August 2015 report, the focus of this report is on the FutureFuel facility. The remainder of this report documents the air dispersion modeling methodology, data resources and model results used to determine attainment of the 1-hour SO_2 NAAQS in Independence County.

[1] *Air Quality Designations for the 2010 Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard-Round 2*, 81 FR 45039, July 12, 2016.

2. FACILITY DESCRIPTION

This section presents a description of the FutureFuel Chemical Company facility location and site characteristics required as part of the air dispersion modeling evaluation. Refer to the August 2015 report for details on the Entergy Independence Station.

2.1. FACILITY LOCATION

FutureFuel is located approximately 12 kilometers (km) southeast of Batesville in Independence County, Arkansas. Figure 2-1 provides a map of the area surrounding FutureFuel's property. The approximate central Universal Transverse Mercator (UTM) coordinates of the facility are 633,080 meters east and 3,953,700 meters north in Zone 15 [North American Datum 1983 (NAD 83)]. As shown in Figure 2-1, the facility is located in a very rural area of the White River valley, comprised of mixed forest and agricultural land with flat, rolling and hilly terrain all nearby.

Figure 2-1. Map of Area Surrounding FutureFuel Chemical

Figure 2-2 shows the relative locations of FutureFuel and Entergy. Entergy is located approximately 11.4 km southeast of FutureFuel and is in an area of generally flat terrain.

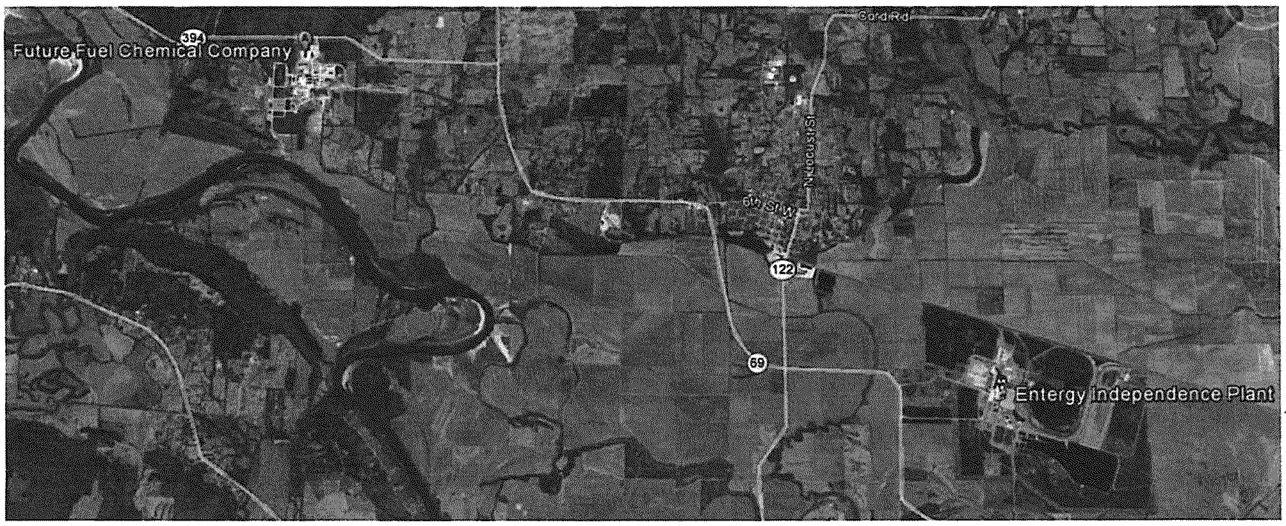

Figure 2-2. Relative Locations of FutureFuel and Entergy

Figure 2-3 shows an aerial photograph of FutureFuel with the SO_2 sources labeled. Figure 2-4 presents a plot plan of FutureFuel showing the major buildings and SO_2 sources. Refer to Entergy's August 2015 report for more details about their site and SO_2 emissions.

Figure 2-3. Aerial Photograph of FutureFuel SO_2 Sources

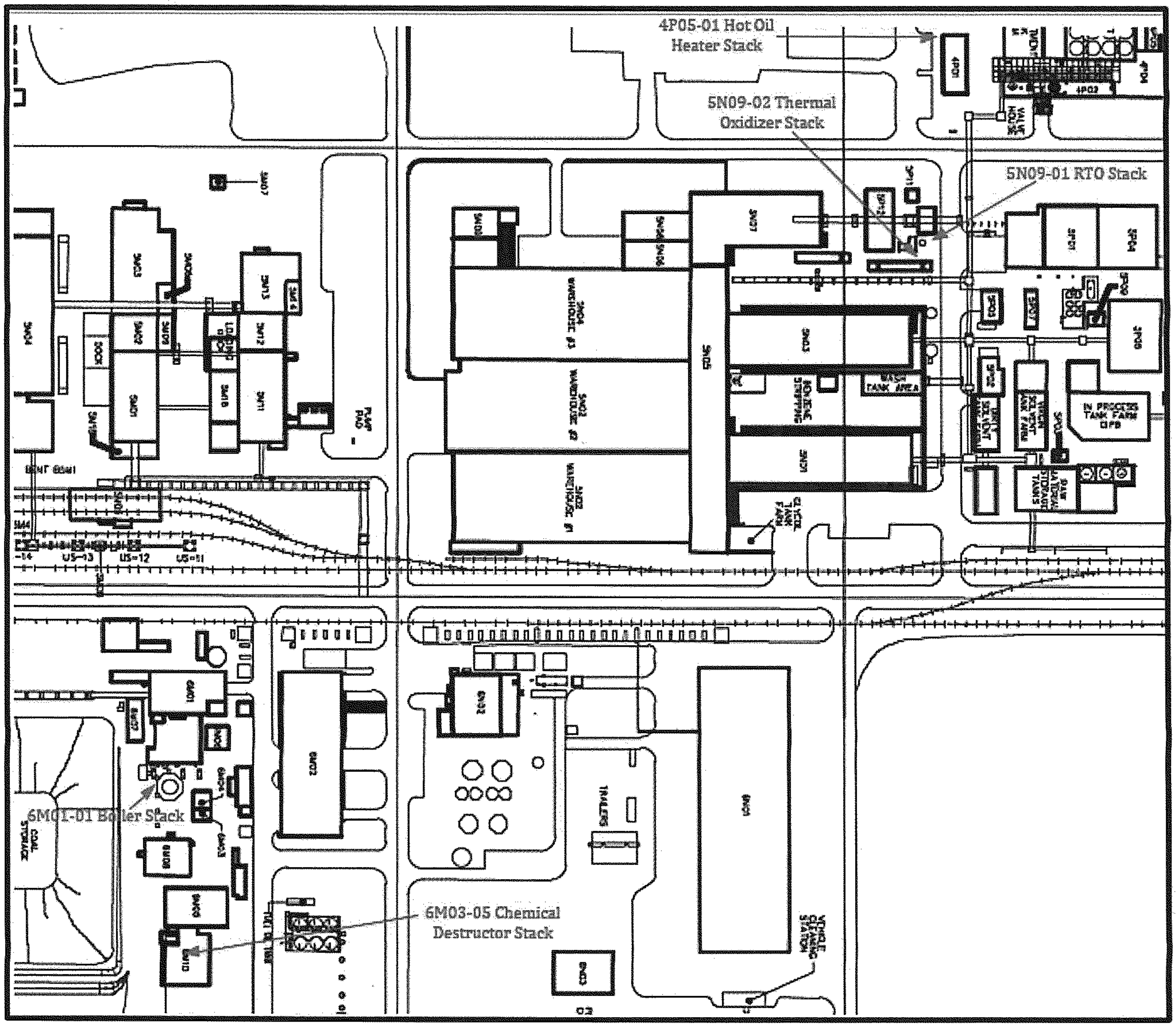

Figure 2-4. FutureFuel Plot Plan

3. DISPERSION MODELING ANALYSIS

This section presents the input data and modeling methodology utilized in the SO_2 NAAQS modeling demonstration. The modeling methodology conforms to the EPA's SO_2 NAAQS Designations Modeling Technical Assistance Document (TAD).[2]

3.1. MODEL SELECTION

Modeling was performed for the 1-hour SO_2 analysis following the Modeling TAD. AERMOD Model Version 15181, the most current version available at the time of this analysis, was used to perform the dispersion modeling. The proposed update to EPA's modeling guidance in the form of the *Guideline on Air Quality Models*[3], was released on July 15, 2015 via the EPA technical website.[4]

3.2. SOURCE DESCRIPTION

All SO_2 emitting sources at Entergy and FutureFuel were modeled except for five (5) small SO_2 emitting FutureFuel sources (less than 3.8 lb/hr total) and five (5) intermittent emergency FutureFuel sources such as an emergency diesel-fired generator and fire water pump engines. Sources combusting only pipeline quality natural gas have negligible SO_2 emissions and were generally not included in the model. However, the Hot Oil System (4P05_01) has a relatively low stack and was included as a worst case. See Appendix B for a more detailed justification of the FutureFuel sources not included in this analysis. The modeled sources account for 98.5% of allowable SO_2 emissions from the facility. Table 3-1 presents a table of the modeled sources and their locations. All locations are expressed in UTM Zone 15 coordinates.

Table 3-1. Modeled Sources and Locations

Model ID	Description	UTM-E (m)	UTM-N (m)	Elevation (m)
5N09_01	Regenerative Thermal Oxidizer (RTO)	633,660.39	3,953,915.79	81.94
6M01_01	Coal Fired Boilers	633,343.50	3,953,692.29	83.57
6M03_05	Chemical Waste Destructor	633,336.15	3,953,628.65	81.50
4P05_01	Hot Oil Heater	633,692.56	3,954,022.81	83.40
5N09_02	Thermal Oxidizer/Caustic Scrubber	633,629.84	3,953,907.38	83.86

[2] http://www.epa.gov/airquality/surfurdioxide/pdfs/SO2ModelingTAD.pdf

[3] *Guideline on Air Quality Models.* Appendix W to 40 CFR Parts 51 and 52. Federal Register, November 9, 2005. pp. 68217-68261.

[4] http://www.epa.gov/ttn/scram/

All sources are point sources with vertically oriented stacks and Table 3-2 presents the stack parameters input for each of the sources. Stack temperature and exit velocity are not measured at any FutureFuel sources. Therefore, these parameters are constants in the model and are based on recent stack test measurements (or equipment design) indicative of actual operation during the modeled period.

Table 3-2. Modeled Source Parameters

Model ID (Description)	Stack Height (m)	Stack Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)
5N09_01 (RTO)	18.29	390.3 [a]	9.6 [a]	2.44
6M01_01 (Boilers)	60.96	519.0 [b]	14.4 [b]	2.74
6M03_05 (Chemical Waste Destructor)	26.57	357.9 [c]	11.0 [c]	1.22
4P05_01 (Hot Oil Htr)	5.20	477.6 [d]	2.7 [d]	0.46
5N09_02 (TO / Scrubber)	7.62	345.2 [e]	9.3 [e]	0.24

[a] The RTO (5N09_01) stack temperature and exit velocity are based on a February 27, 2014, stack test representative of actual operating conditions.

[b] The coal fired boiler (6M01_01) stack temperature is estimated based on the 515 °F inlet temperature to the air pollution control device (ESP) measured during a November 1997 test. The exit velocity is based on a February 9, 2015, engineering stack test representative of actual operating conditions.

[c] The chemical waste destructor (6M03_05) stack temperature and exit velocity values are averages based on four stack tests conducted August 16, 2011; November 27, 2012; April 9, 2013; and August 20, 2013.

[d] The hot oil heater (4P05_01) stack temperature and exit velocity are based on engineering judgment and equipment design.

[e] The TO/caustic scrubber (5N09_02) stack temperature and exit velocity are based on an August 23, 2013, stack test representative of actual operating conditions.

3.3. MODELED EMISSION RATES

As described in the Modeling TAD, attainment modeling demonstrations are intended to represent actual facility emissions. FutureFuel does not operate any SO_2 continuous emissions monitoring systems (CEMS). Therefore, SO_2 emission rates are based on mass balances maintained for the chemical manufacturing processes, or in the case of the boilers, fuel sulfur balances. Each source is described below and the actual emission rates and calculation basis for each is explained further in Appendix C.

FutureFuel manufactures a wide variety of organic chemical intermediates using primarily batch processes. The RTO (5N09_01) is used to control process VOC emissions from the solvent recovery facility, the aldehyde procession section, and the anode material process. The Thermal Oxidizer/Caustic Scrubber (5N09_02) is an oxidizer used to control process VOC emissions from the organic chemical intermediates (OCI) production facilities. Depending on the chemicals being manufactured, process emissions may contain small quantities of sulfur-containing compounds which can be oxidized to SO_2 in the RTO and/or oxidizers.

The boilers (6M01_01) consist of three coal-fired boilers exhausting through a single stack. The boilers are rated at 70 MMBtu/hr each. During the modeled period, these boilers burned bituminous Illinois coal with a sulfur content ranging from 2.3 percent to 3.5 percent. The boilers are the largest SO_2 emitting sources by two orders of magnitude, and additional documentation on boiler coal usage and coal sulfur content during the modeled period is included in Appendix D.

The chemical waste destructor (6M03_05) is designed to burn a mixture of waste streams resulting from various fine chemical manufacturing processes. Some waste is organic solvents, but the majority is comprised of aqueous solutions containing organic and salt compounds. The chemical destructor is a vertically down fired unit. As with the oxidizers, any sulfur-containing compounds in the waste streams will be converted to SO_2 in the chemical waste destructor.

FutureFuel maintains chemical mass balance and fuel usage records on a monthly basis. Four of the five modeled sources used actual monthly average emissions data for the 2012-2014 period. For the lowest emitting unit (TO/Scrubber 5N09_02), actual emissions data were not available and the maximum hourly allowable permit limit (3.0 lb/hr SO_2) was modeled as a worst-case. The EMISFACT option in AERMOD was utilized to supply the varying monthly emission rates for the units with monthly emission rate data. See Appendix C for presentation of actual emission rates and discussion of the EMISFACT option. Table 3-3 shows the annual average hourly emission rate for comparison purposes.

Table 3-3. Average Modeled SO_2 Emission Rates

Model ID	2012 Average Emission Rate (lb/hr)	2013 Average Emission Rate (lb/hr)	2014 Average Emission Rate (lb/hr)
5N09_01	0.09	0.09	0.05
6M01_01	560.0	604.7	697.6
6M03_05	2.53	4.41	3.49
4P05_01	0.00005	0.00006	0.00006
5N09_02	3.00	3.00	3.00

Note: The Entergy emission rates are described in their August 2015 report.

3.4. BACKGROUND CONCENTRATIONS

Ambient background data from the closest, most representative SO_2 monitor located in Little Rock (Monitor ID# 05-119-0007) was used to represent distant sources of SO_2 in the background. The only other SO_2 monitor in Arkansas is located in El Dorado in the southern portion of the state. EPA Guidance allows the inclusion of background values that vary by season and hour of day that could simulate a lower value than the 99th percentile design value from the monitor. The modeling was performed with a set of seasonal diurnal values originally developed in Entergy's August 2015 report using methodology described in the EPA's March 1, 2011 *Clarification Memorandum for 1-hour NO_2 Modeling*. Table 3-4 shows the seasonal diurnal values used.

Table 3-4. Seasonal Diurnal SO_2 Concentrations at Little Rock Monitor

Hour	Winter (μg/m³)	Spring (μg/m³)	Summer (μg/m³)	Fall (μg/m³)
1	6.89	5.67	4.80	5.50
2	7.85	5.32	4.28	6.19
3	7.33	6.19	4.45	6.02
4	6.89	5.76	4.19	4.71
5	8.55	4.97	4.19	5.15
6	9.60	4.80	5.41	5.85
7	9.60	6.28	5.50	6.63
8	8.99	5.24	6.11	6.54
9	7.50	6.46	7.68	7.85
10	8.38	8.20	7.42	9.07
11	9.16	8.46	9.95	8.20
12	10.73	15.09	10.38	9.34
13	9.69	11.08	10.91	11.17
14	10.56	9.34	9.86	9.51
15	10.03	8.20	13.18	9.95
16	9.42	7.94	9.34	10.47
17	7.15	9.86	11.08	9.16
18	7.50	7.42	9.69	7.24
19	9.25	6.37	9.86	6.98
20	12.30	6.54	8.73	5.93
21	9.07	6.02	6.19	6.28
22	6.11	8.99	5.76	5.67
23	6.46	7.07	5.67	5.85
24	7.24	6.81	5.41	6.11

Figure 3-1 shows the relative locations of FutureFuel, the Entergy Independence Plant, and the Little Rock meteorological site and SO_2 monitor.

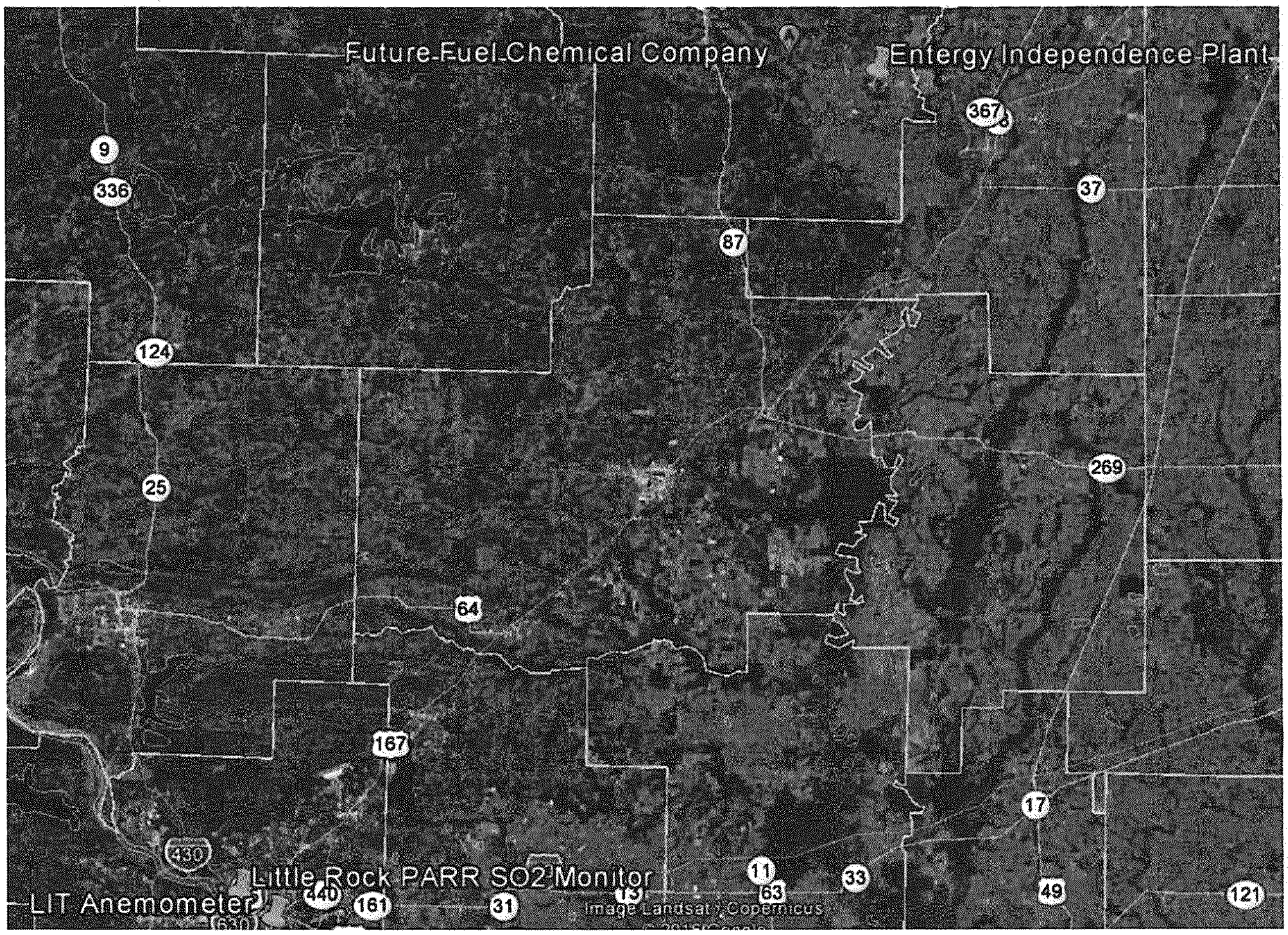

Figure 3-1. Location of FutureFuel, Entergy, and the Little Rock Meteorological and SO_2 Monitor Sites

3.5. METEOROLOGICAL DATA

AERMOD-ready meteorological data for the period 2012-2014 was prepared using the latest version of the EPA's AERMET meteorological processing utility (version 15181). Standard EPA meteorological data processing guidance was used as outlined in a recent memorandum[5] and other documentation.

3.5.1. Surface Data

Raw hourly surface meteorological data was obtained from the U.S. National Climatic Data Center (NCDC) for Little Rock Clinton National Airport/Adams Field (KLIT, WMO ID: 722310) in the standard ISHD format. This data was supplemented with TD-6405 (commonly referred to as "1-minute ASOS") wind data from KLIT. The 1-

[5] Fox, Tyler, U.S. Environmental Protection Agency. 2013. "Use of ASOS Meteorological Data in AERMOD Dispersion Modeling." Available Online: http://www.epa.gov/ttn/scram/guidance/clarification/20130308_Met_Data_Clarification.pdf

minute wind data was processed using the latest version of the EPA AERMINUTE pre-processing tool (version 15272). Quality of the 1-minute data was verified by comparison to the hourly ISHD data from KLIT, which showed only small differences typical of 1-minute and hourly wind data comparisons. The "Ice-Free Winds Group (IFWG)" option was utilized in AERMINUTE due to the fact that a sonic anemometer was installed at KLIT on May 21, 2009. [6] As such, the IFWG option was engaged for the full 2012-2014 period. Figure 3-2 shows the distribution of wind speed and direction for the site.

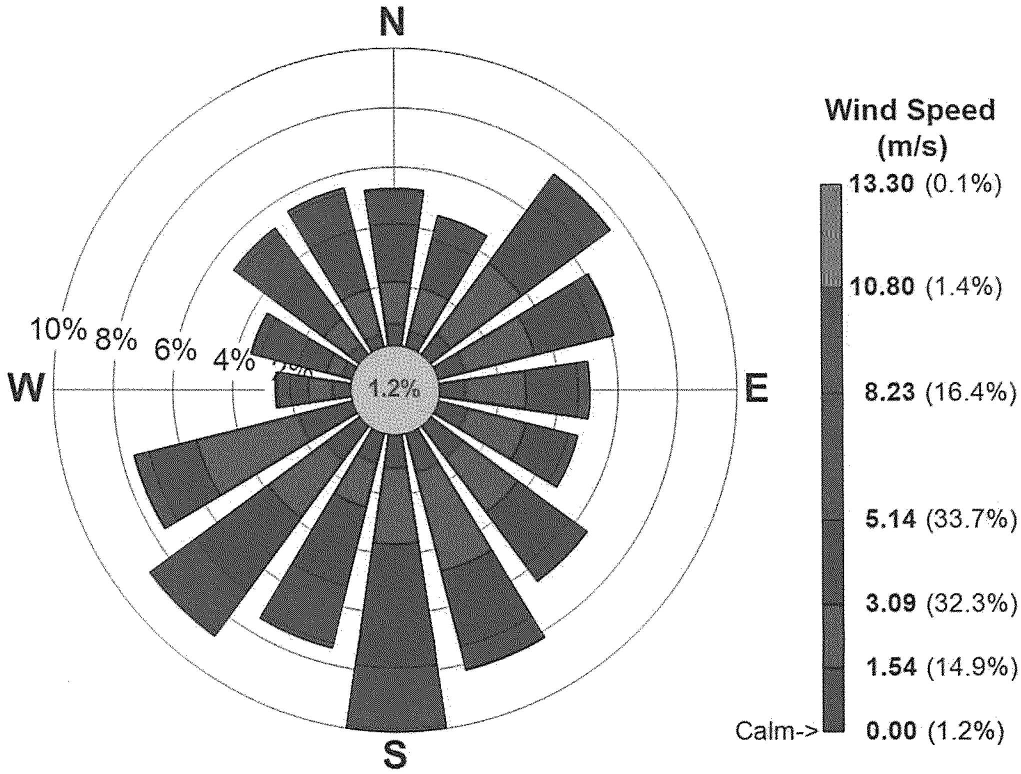

Figure 3-2. 2012-2014 Wind Rose for Little Rock Airport (KLIT)

3.5.2. Upper Air Data

In addition to surface meteorological data, AERMET requires the use of data from a sunrise-time upper air sounding to estimate daytime mixing heights. The nearest U.S. National Weather Service (NWS) upper-air radiosonde station is located in Little Rock, AR (LZK). Upper air data for the same 2012-2014 time period were obtained from the National Oceanic and Atmospheric Administration (NOAA) in FSL format.[7]

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[6] http://www.nws.noaa.gov/ops2/Surface/documents/IFW_stat.pdf

[7] http://esrl.noaa.gov/raobs/

3.5.3. Land Use Analysis

Parameters derived from the analysis of land use data (surface roughness, Bowen ratio, and albedo) are also required by AERMET. In accordance with EPA guidance, these values were determined using the latest version of the EPA AERSURFACE tool (version 13016).[8] The AERSUFACE settings used for processing are summarized in Table 3-5. The met station coordinates were determined by visually identifying the met station in Google Earth. NLCD 1992 (CONUS) Land Cover data used in AERSURFACE processing was obtained from the Multi-Resolution Land Use Consortium (MRLC).

EPA guidance dictates that on at least an annual basis, precipitation at a surface site should be classified as wet, dry, or average in comparison to the 30-year climatological record at the site. This determination is used to adjust the Bowen ratio estimated by AERSURFACE. To make the determination, annual precipitation in each modeled year (2012-2014) was compared to the 1981-2010 climatological record for KLIT.[9] The 30th and 70th percentile values of the annual precipitation distribution from 1981-2010 were calculated. Per EPA guidance, each modeled year was classified for AERSUFACE processing as "wet" if its annual precipitation was higher than the 70th percentile value, "dry" if its annual precipitation was lower than the 30th percentile value, and "average" if it was between the 30th and 70th percentile values. The values used in this case are included in Table 3-5.

Table 3-5. AERSURFACE Input Parameters

AERSURFACE Parameter	Value
Met Station Latitude	34.727266
Met Station Longitude	-92.235811
Datum	NAD 1983
Radius for surface roughness (km)	1.0
Vary by Sector?	Yes
Number of Sectors	12
Temporal Resolution	Seasonal
Continuous Winter Snow Cover?	No
Station Located at Airport?	Yes
Arid Region?	No
Surface Moisture Classification	Dry (2012), Wet (2013), Average (2014)

EPA recommendations were used to specify the area used for the AERSURFACE analysis. Surface roughness was estimated based on land use within a 1 km radius of the meteorological station, with directional variation in roughness accounted for by using the maximum of twelve, thirty-degree sectors. Albedo and Bowen ratio were estimated based on a 10x10 km box centered on the meteorological station. Figure 3-3 shows the areas used for the land use analysis.

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[8] U.S. Environmental Protection Agency. 2013. "AERSURFACE User's Guide." EPA-454/B-08-001, Revised 01/16/2013. Available Online: http://www.epa.gov/scram001/7thconf/aermod/aersurface_userguide.pdf

[9] National Climatic Data Center. 2010 Local Climatological Data (LCD), (KMSY).

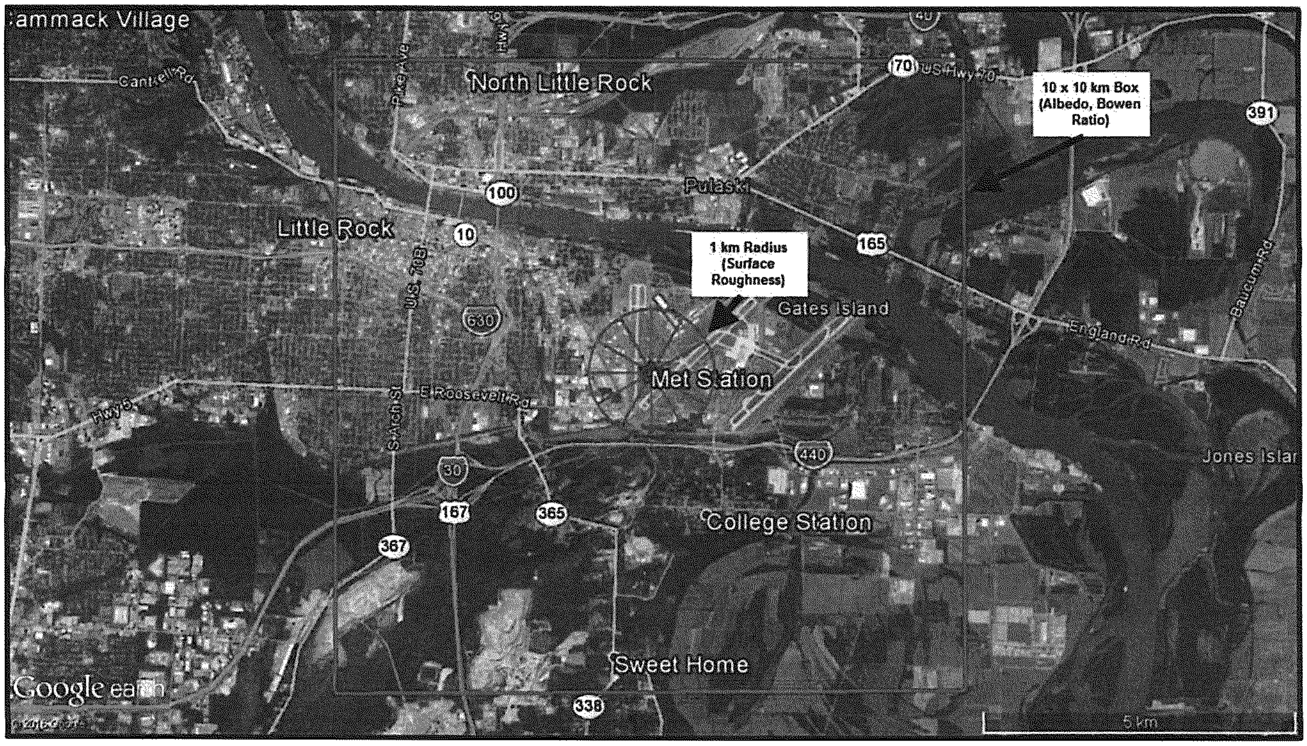

Figure 3-3. Areas Used for AERSURFACE Land Use Analysis

3.5.4. AERMET Processing Options

EPA released AERMET Version 12345 which included a beta option, ADJ_U*, to better account for turbulence in the atmosphere during low wind speed stable conditions. Subsequent releases of AERMET (including version 15181) have incorporated modifications to the ADJ_U* formulation to better address micrometeorological refinements (e.g. Bulk Richardson Number, low solar elevation angles). The ADJ_U* option adjusts the surface friction velocity parameter (U*) used by AERMET in certain low wind speed situations. This option, based on a peer-reviewed study[10], was added to AERMET by EPA to address the tendency of AERMET/AERMOD to underestimate dispersion and thus overestimate ground-level pollutant concentrations for low-level sources under low wind speed conditions, especially for shorter-term averaging periods.

Given the refined nature of this beta option, the peer reviewed studies, and the site-specific demonstration provided in ADEQ's October 2016 model performance report to EPA, ADEQ has incorporated this AERMET option into the modeling analysis to allow more representative and more accurate modeling results. It is anticipated that the ADJ_U* correction will become a regulatory default in the forthcoming revisions to the EPA *Guideline on Air Quality Models.* [11]

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[10] Qian and Venkatram. 2011. "Performance of Steady-State Dispersion Models Under Low Wind-Speed Conditions." *Boundary-Layer Meteorology*, Volume 138, Issue 3, pp 475-491.

[11] http://www3.epa.gov/ttn/scram/11thmodconf/EPA-HQ-OAR-2015-0310-0001.pdf

The AERMET data processing procedure utilized regulatory default options in this case[12,13] with the exception of the ADJ_U* option. The options selected include:

- MODIFY keyword for upper air data
- THRESH_1MIN 0.5 keyword to provide a lower bound of 0.5 m/s for 1-minute wind data
- AUDIT keywords to provide additional QA/QC and diagnostic information
- ASOS1MIN keyword to incorporate 1-minute wind data
- NWS_HGT WIND 10 keyword to designate the anemometer height as 10 meters
- METHOD WIND_DIR RANDOM keyword to correct for any wind direction rounding in the raw ISHD data
- METHOD REFLEVEL SUBNWS keyword to allow use of airport surface station data
- Default substitution options for cloud cover and temperature data were not overridden
- Default ASOS_ADJ option for correction of truncated wind speeds was not overridden
- ADJ_U* beta option was used

3.6. MODELED RECEPTORS

A comprehensive Cartesian receptor grid extending out to approximately 20 kilometers from FutureFuel and Entergy was used in the AERMOD modeling analysis to assess maximum ground level 1-hour SO_2 concentrations. The Modeling TAD states that the receptor grid must be sufficient to determine ambient air quality in the vicinity of the source being studied. Preliminary modeling analyses were conducted to determine appropriate extents for the modeled receptor grids, which will consist of the following:

- 50-meter spacing along both facility fencelines (fenceline grids);
- 100-meter spacing extending from the Entergy fenceline to 5 kilometers (Entergy fine grid);
- 100-meter spacing extending from the FutureFuel fenceline to 7 kilometers (FutureFuel fine grid);
- 200-meter spacing extending from 7 to 10 kilometers around FutureFuel (FutureFuel medium grid); and
- 500-meter spacing extending from 10 to 20 kilometers around FutureFuel (FutureFuel coarse grid); and
- 1,000-meter spacing extending out 20 kilometers around both facilities (Overall coarse grid).

The above receptor data will be used without modification in the modeling. Per the Modeling TAD, a number of receptors located over the White River could be excluded from the modeling domain because ambient monitors could not reasonably be placed at these locations, but these receptors will be retained in this analysis as a measure of conservatism.

The AERMOD model is capable of handling both simple and complex terrain. Through the use of the AERMOD terrain preprocessor (AERMAP), AERMOD incorporates not only the receptor heights, but also an effective height (hill height scale) that represents the significant terrain features surrounding a given receptor that could lead to plume recirculation and other terrain interaction.[14] Receptor terrain elevations input to the model will be interpolated from National Elevation Database (NED) data obtained from the USGS. NED data consist of arrays of regularly spaced elevations. The array elevations will be at a resolution of 1 arc second (approximately

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[12] Fox, Tyler, U.S. Environmental Protection Agency. 2013. "Use of ASOS Meteorological Data in AERMOD Dispersion Modeling." Available Online: http://www.epa.gov/ttn/scram/guidance/clarification/20130308_Met_Data_Clarification.pdf

[13] U.S. Environmental Protection Agency. 2014. "User's Guide for the AERMOD Meteorological Preprocessor (AERMET)". EPA-454/B-03-002, November 2004).

[14] US EPA· *Users Guide for the AERMOD Terrain Preprocessor (AERMAP)*, EPA-454/B-03-003, Research Triangle Park, NC.

30 m intervals) and will be interpolated using the latest version of AERMAP (version 11103) to determine elevations at the defined receptor intervals. The receptor grids that will be modeled are shown in Figure 3-4.

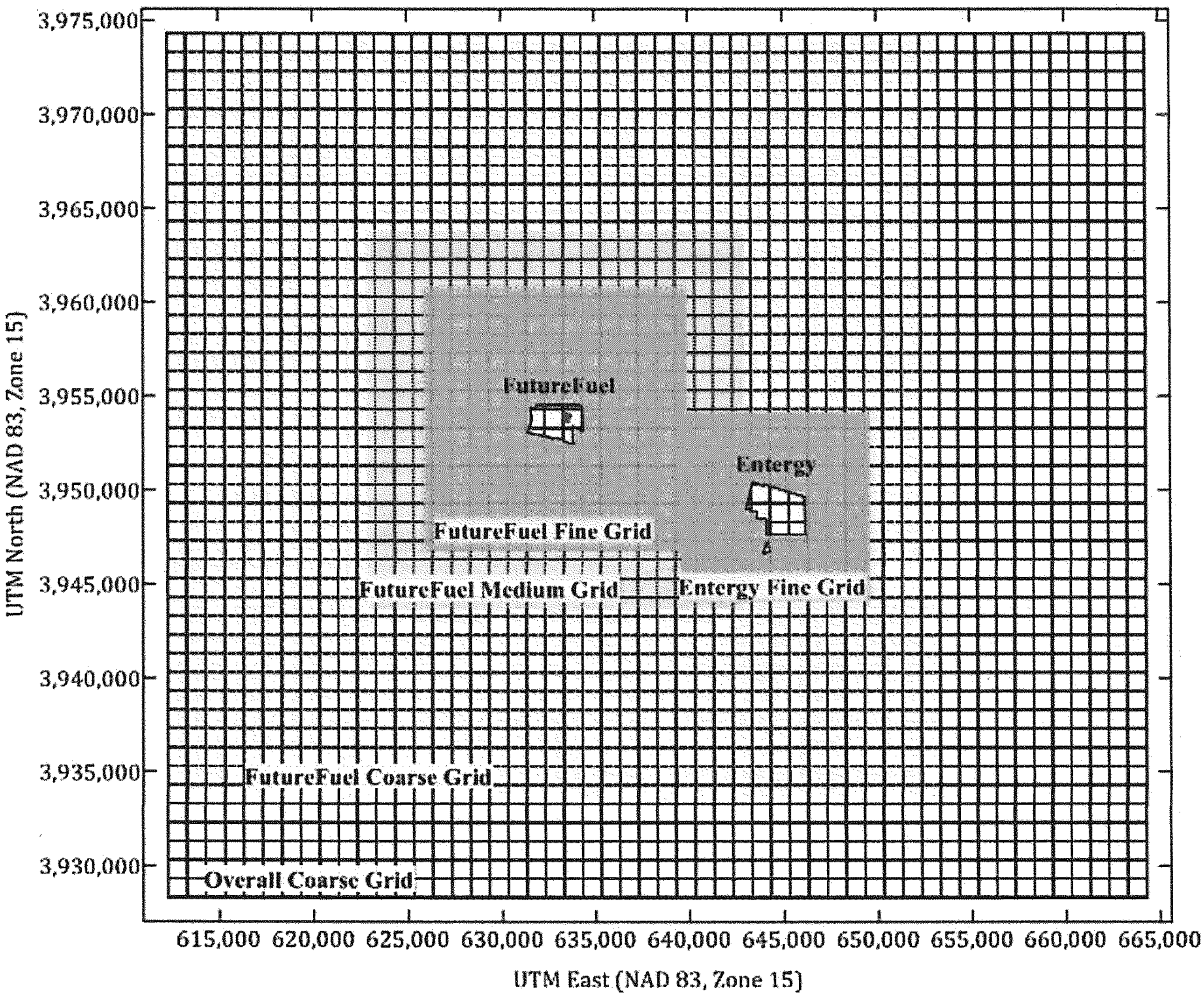

Figure 3-4. Receptor Grids